

LabVIEW Measurement Automation and Applications

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What is the hardware that we have?



- Keithley 237s (V/I sources and V/I meters)



- 2 probe stations – one with homemade dark box

- HP 4284A (LCR meter) – external DC bias using K237, K485 pAmmeter



- voltage sources

*Grezgorz Deptuch

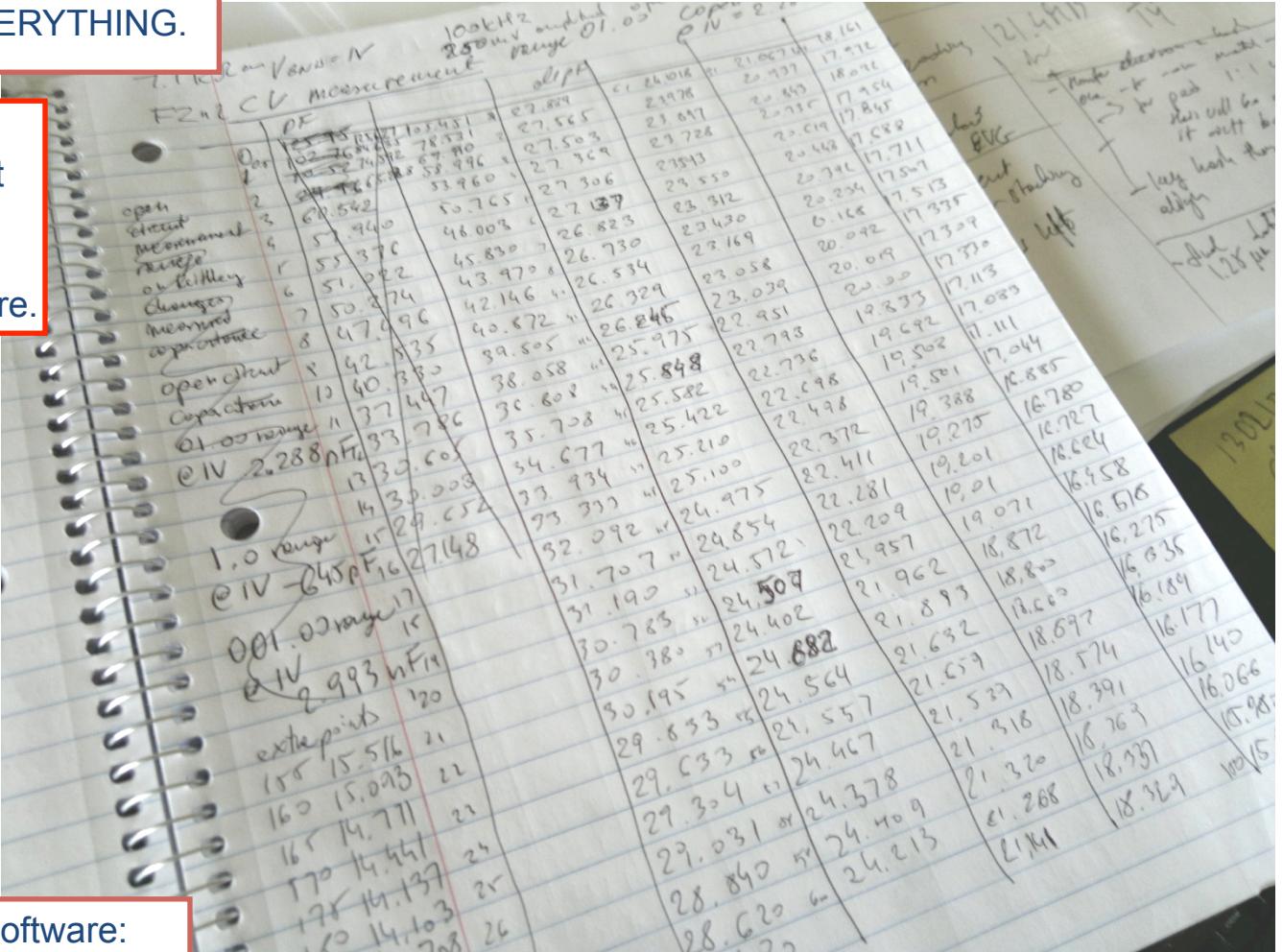
HARDWARE IS NOT EVERYTHING.

- Tedious pen-and-paper method is the last resort when measurement hardware is not accompanied by software.



Software:

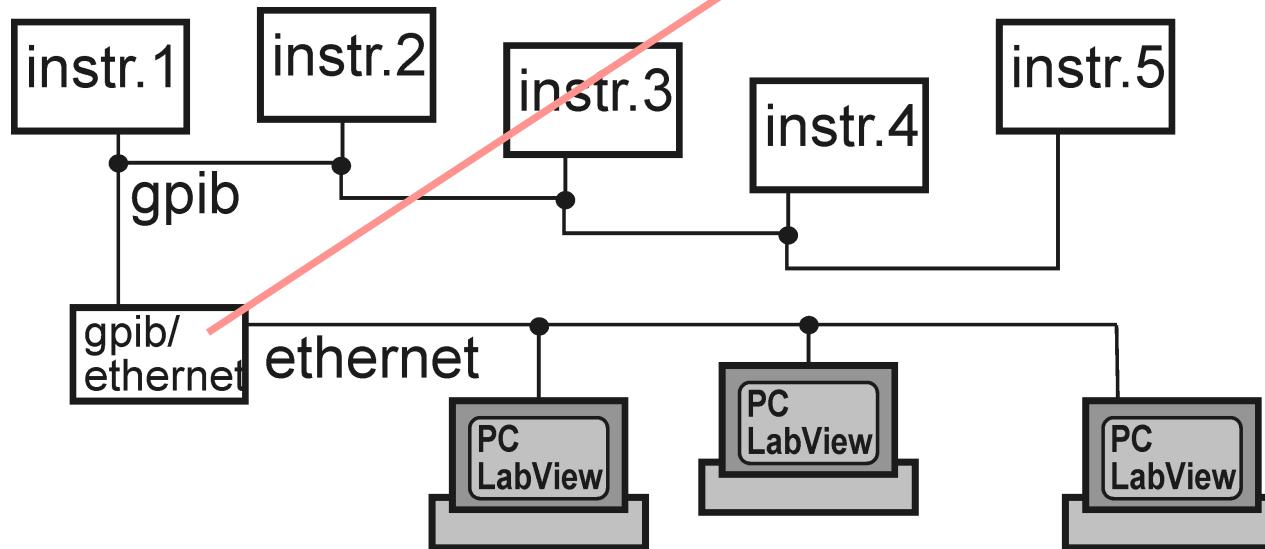
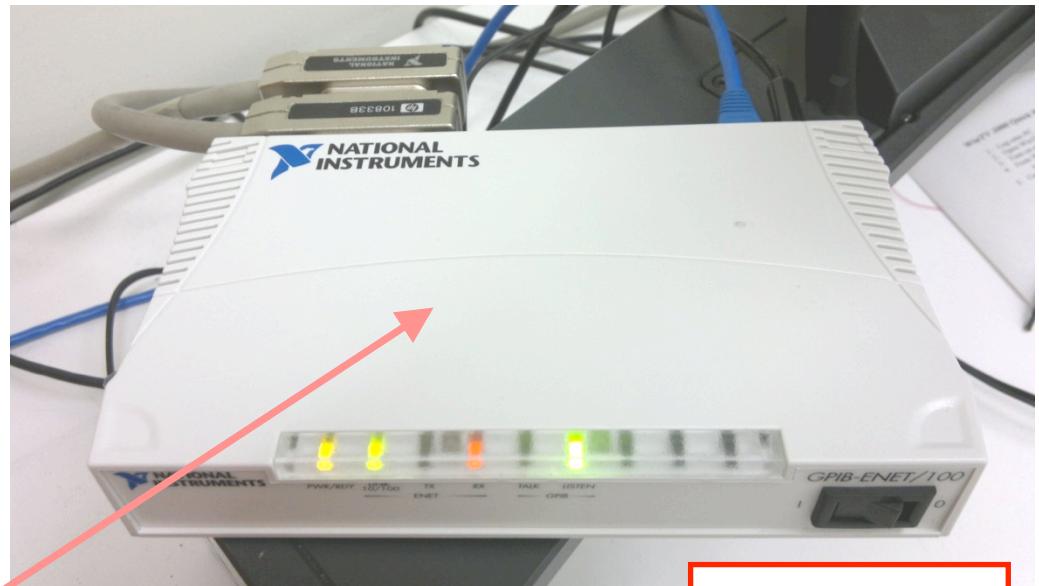
- Should include features and realize methods that are exactly needed!
- Should allow modifications and additions if new instruments are added.
- Should be developed in limited time and with reasonable resources.



*Grezgorz Deptuch

HOW WE BUILT OUR SYSTEM

- All measurement instruments are connected (bus) by GPIB.
- All instruments are in “clean room” on the 14th floor of Wilson Hall.
- GPIB converted to Ethernet
- All measurement instruments are seen on remote computers as they were connected locally.

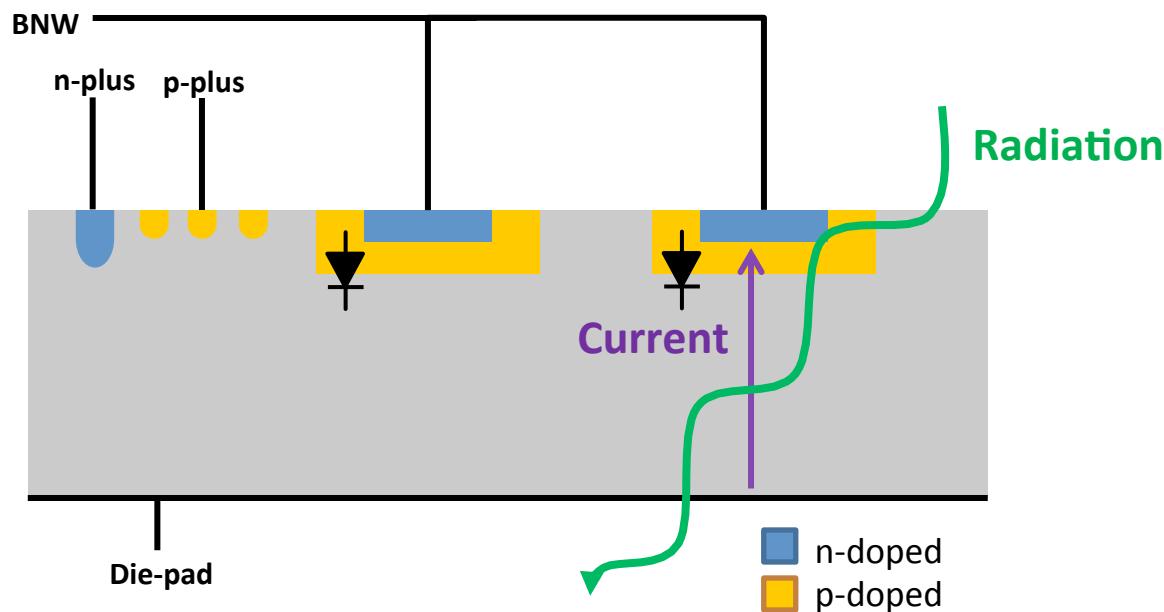
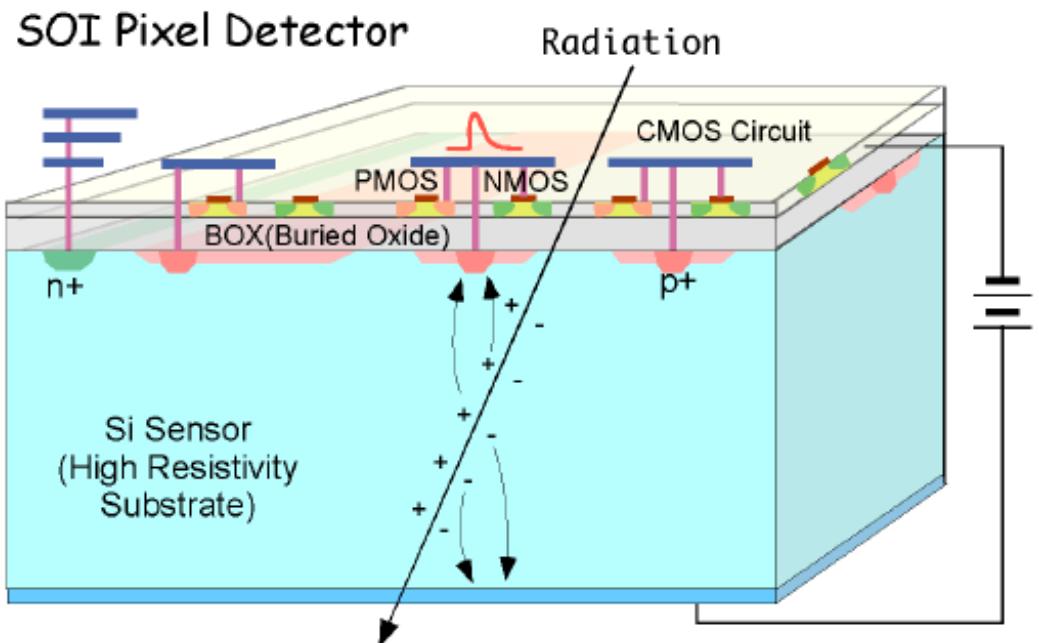


GPIB-ENET/100

- All instruments can be accessed from LabVIEW.
- Measurements are performed using LabVIEW routines.
- Visualization and processing done in LabVIEW or Origin

Complex Detectors

One pixel detector is the Monolithic Active Pixel Matrix with Binary Counters (MAMBO) having a Buried P-doped Well (BPW) and a Buried N-doped Well (BNW). The BNW is there to protect the amplifying transistors from the changing bias in the BPW caused by the radiation.



LabVIEW I-V

Current vs Voltage Measurement with KEITH 237 METER/DC VOLTAGE/DC CURRENT SOURCE and other instruments

SETUP OF KEITHLEY 237

VISA resource name: GPIB0::10::INSTR 1100V ENABLED

source range I source / V source: auto / auto

integration time (medium:1): fast period

source/measure: voltage/current

current compliance: 0.10000

GPIB timeout [ms]: 4000

filter (disabled:0)

Save?

SETUP OF MEASUREMENT

FORWARD: Volts (green), milliAmps (dark green). start level f: 0.570, stop level f: 1.670, step f: 0.010

BACKWARD: Volts (green), milliAmps (dark green). start level b: 1.500, stop level b: 0.000, step b: 0.010

FILTERING: Forward? (green), Backward? (dark green). step delay time (ms): 10.00, hold time (ms): 10.00. No of meas: 1, No for avg: 1

Bypass: START, CLOSE, GPIB: 0:10

DATA: FORWARD: FVoltage: 1.68, FCurrent: 80.09u; BACKWARD: BVoltage: 0, BCurrent: -7.2525p

ARE OTHER INSTRUMENTS PRESENT

Instr1 Keithley485_A

Instr2 Keithley485_B

Instr3 Keithley237B

Instr4 Keithley2400

gpib1: 0:7, gpib2: 0:15, gpib3: 0:15, gpib4: 0:24

Description of measurement: Room temp=23.5C

Plot 0

FORWARD: Plot of measured vs source. Y-axis: 0E+0 to 3.5E-1. X-axis: 5E-1 to 1.8E+0. Data points form a straight line from (0.57, 0) to (1.67, 0.35).

BACK: Plot of measured vs source. Y-axis: -3E-11 to 3E-11. X-axis: 0E+0 to 1.5E+0. Data points form a straight line from (0.57, 0) to (1.67, 0).

error out: error code: 0, source

device dependent errors: --IDDCO

Instr1: PICOAMMETER Keith485_A

VISA resource name 1: GPIB0::7::INSTR

output_forward: 0.000, range (auto:0)

output_back: 0.000, range (auto:0)

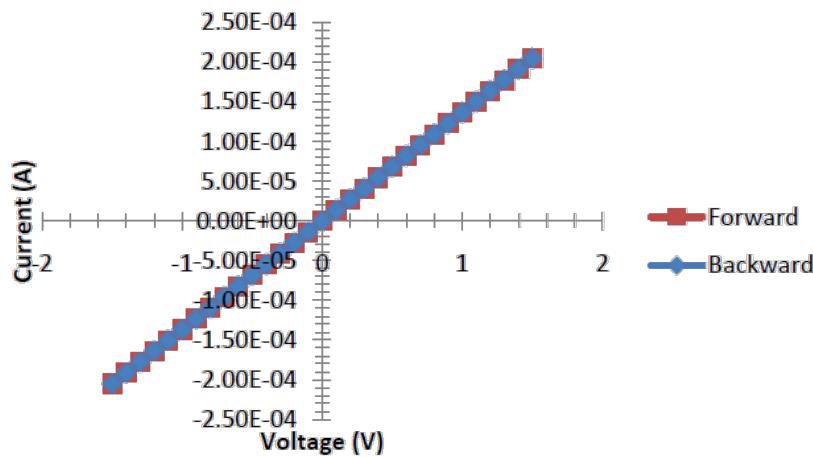
relative (off:0): on-, set-, off-

log: on, off

trigger (cont:0): cont. on talk

Basic Tests

Resistor I vs. V



Resistor
6.8 Kohms +/- 5%

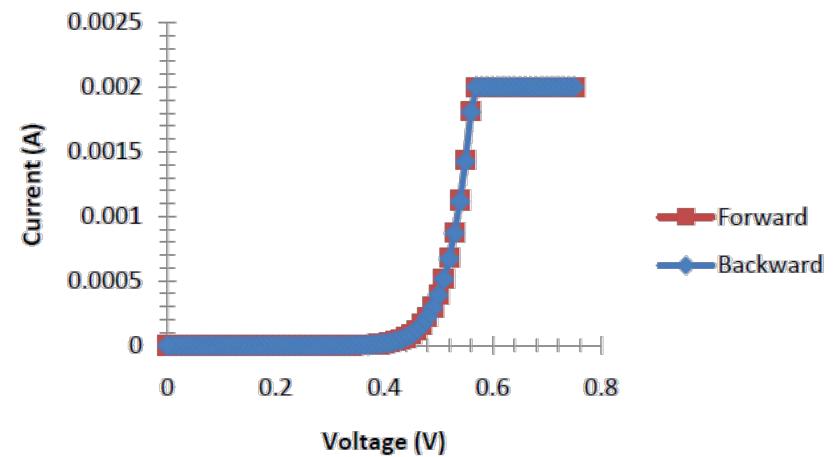


Diode1
IN5401

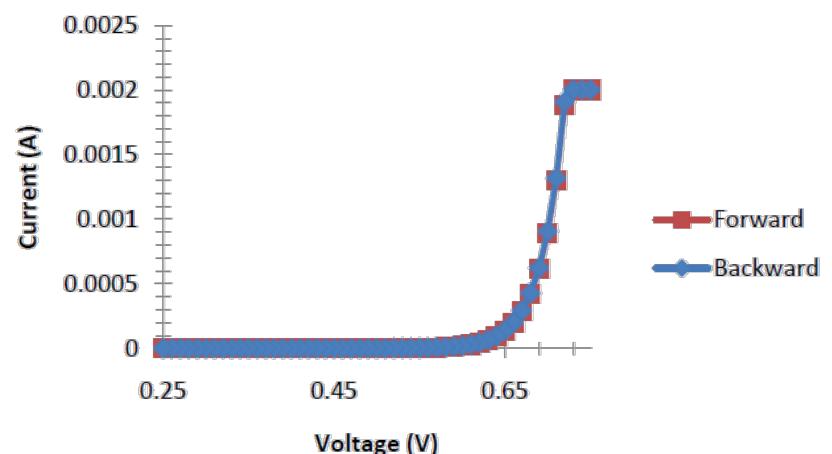


Diode2
IN759

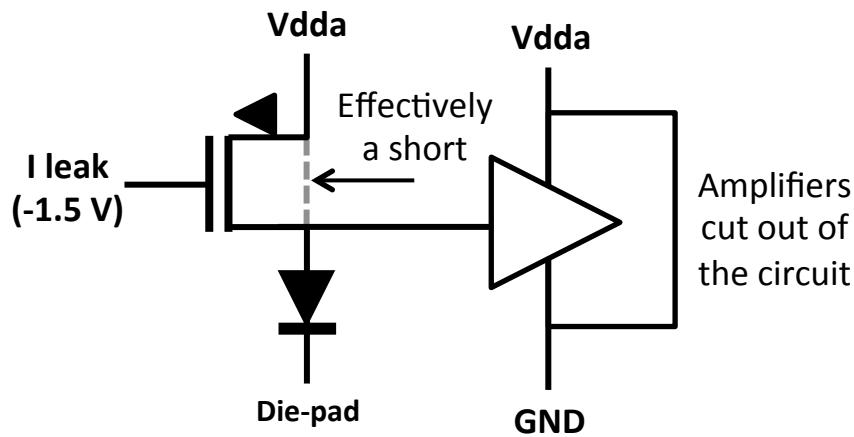
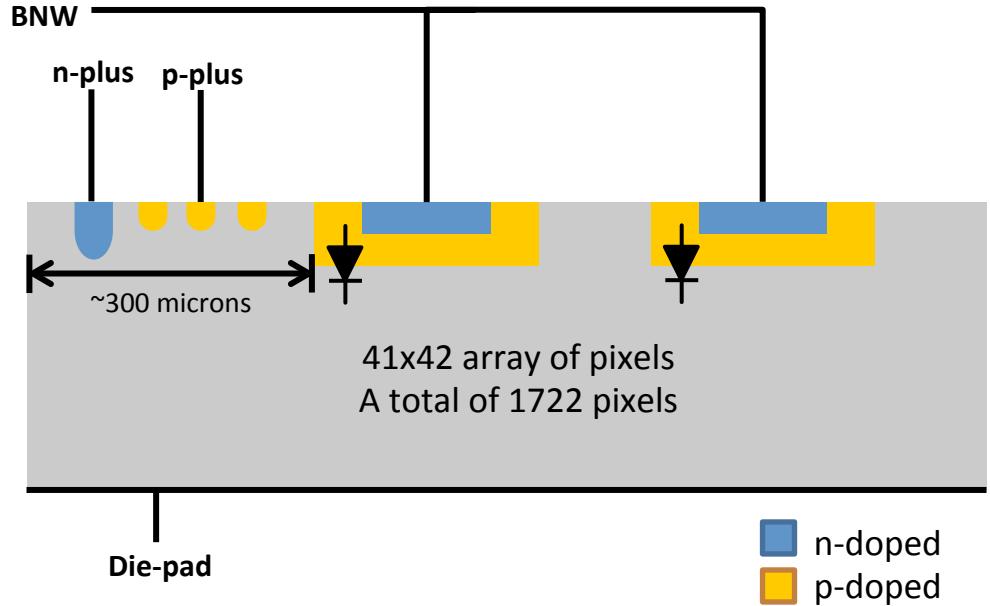
Diode1 I vs. V



Diode 2 I vs. V

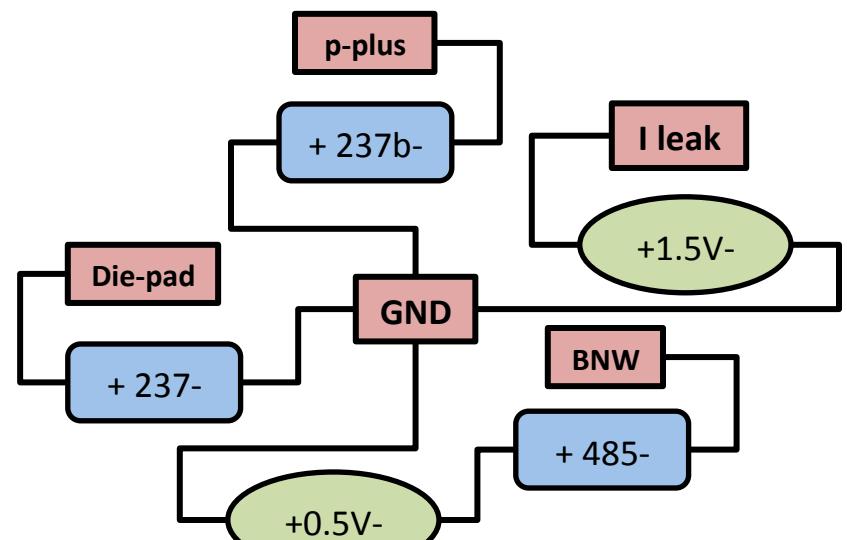


Test Structure: MAMBO IV



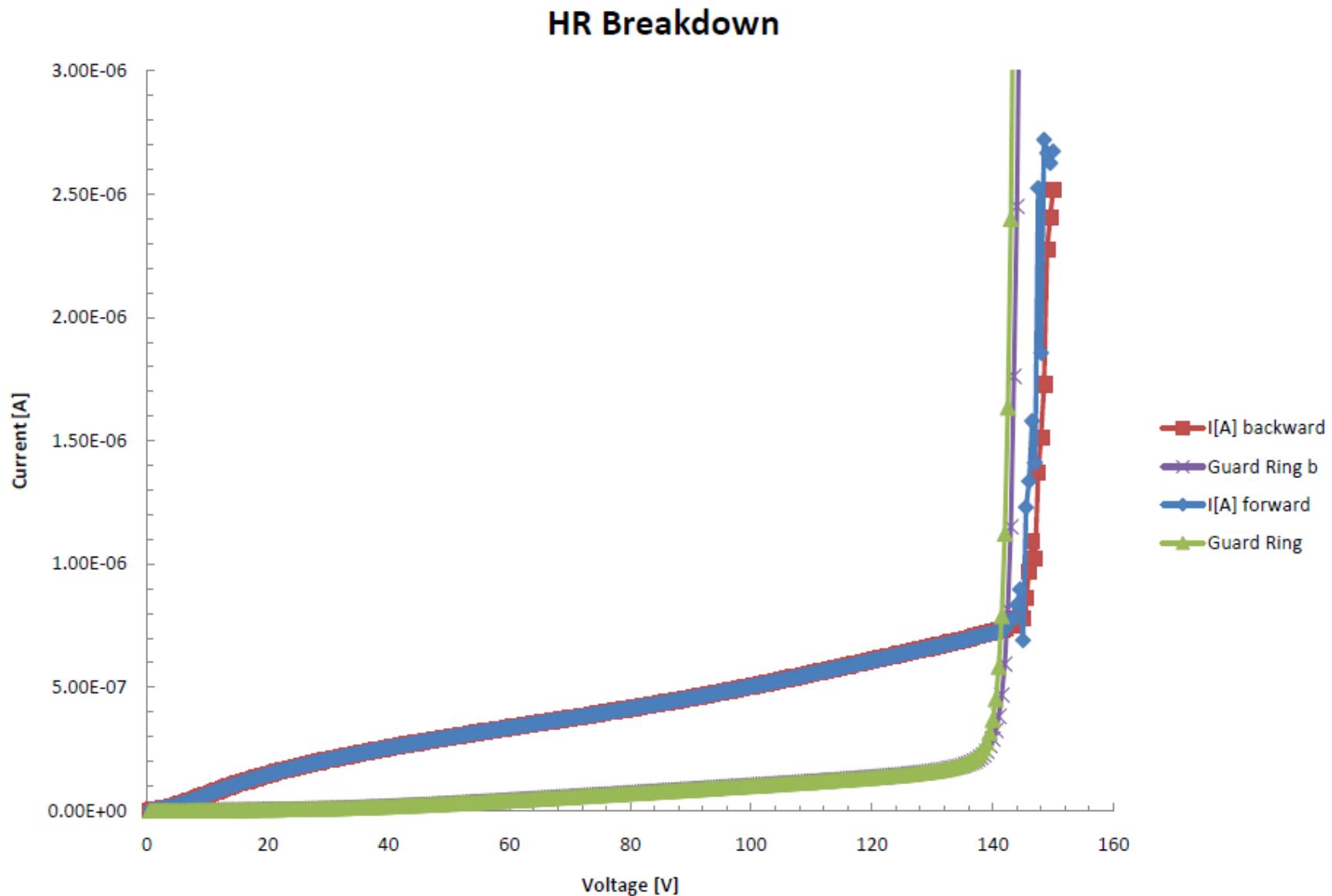
Measurement Devices:
2 Keithley 237: source/measure
1 Keithley 485: picoammeter

Other Devices:
2 Constant Voltage Sources



Control Data

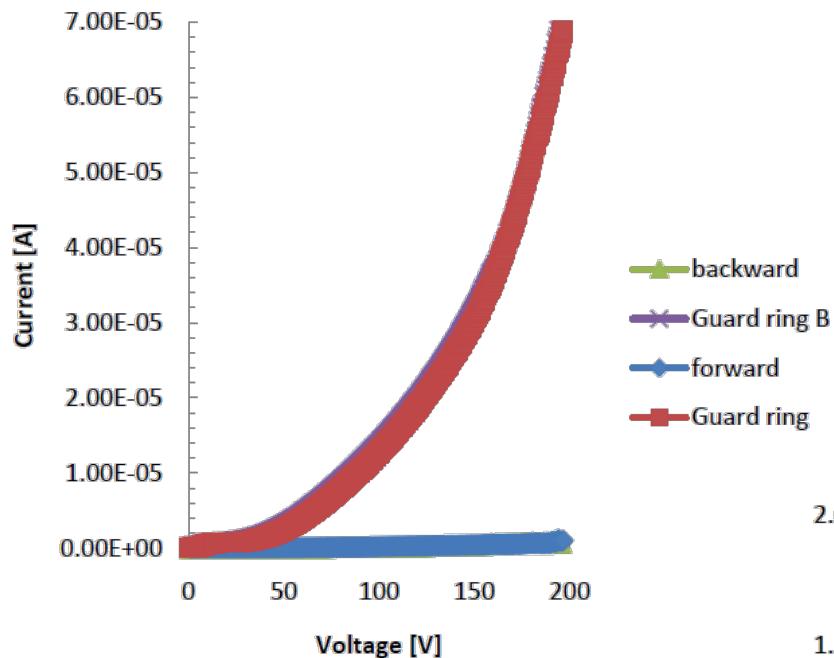
HR: 1 KΩcm Czochralski
Thin: 300 microns



Control Data cont.

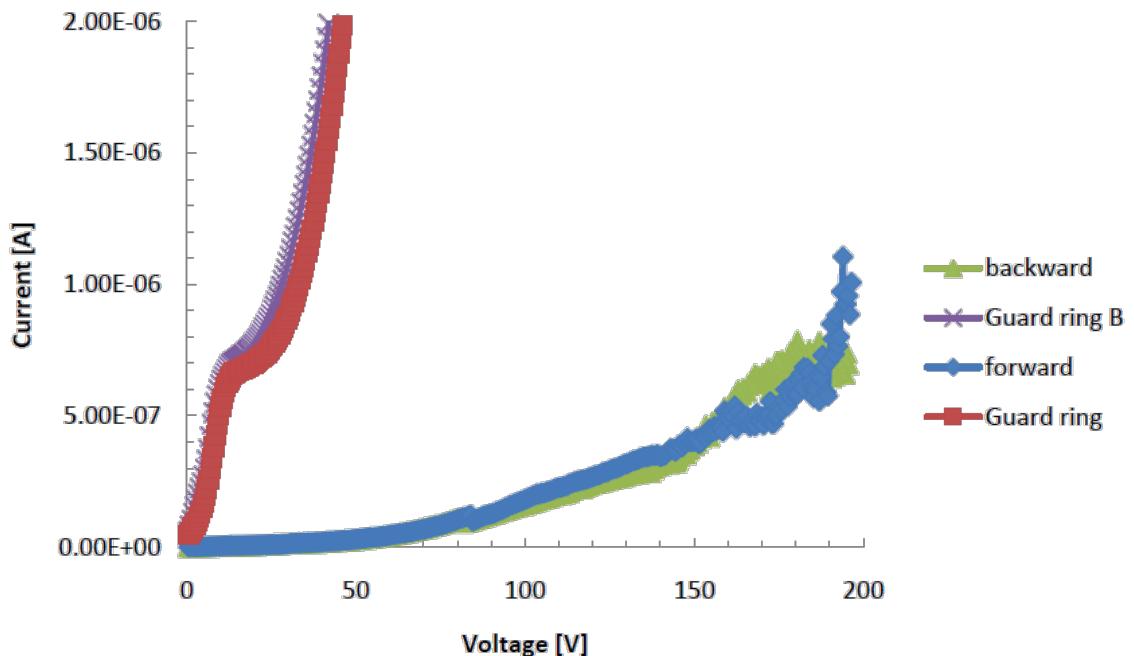
FZ: Float Zone 7.1 KΩcm
Thicker: ~485 microns

FZ: Guard ring and Pixels



No apparent breakdown
Noise from subtracting 2 large numbers for a small one
Averaged over 8 measurements to reduce noise

FZ: Guard ring and Pixels



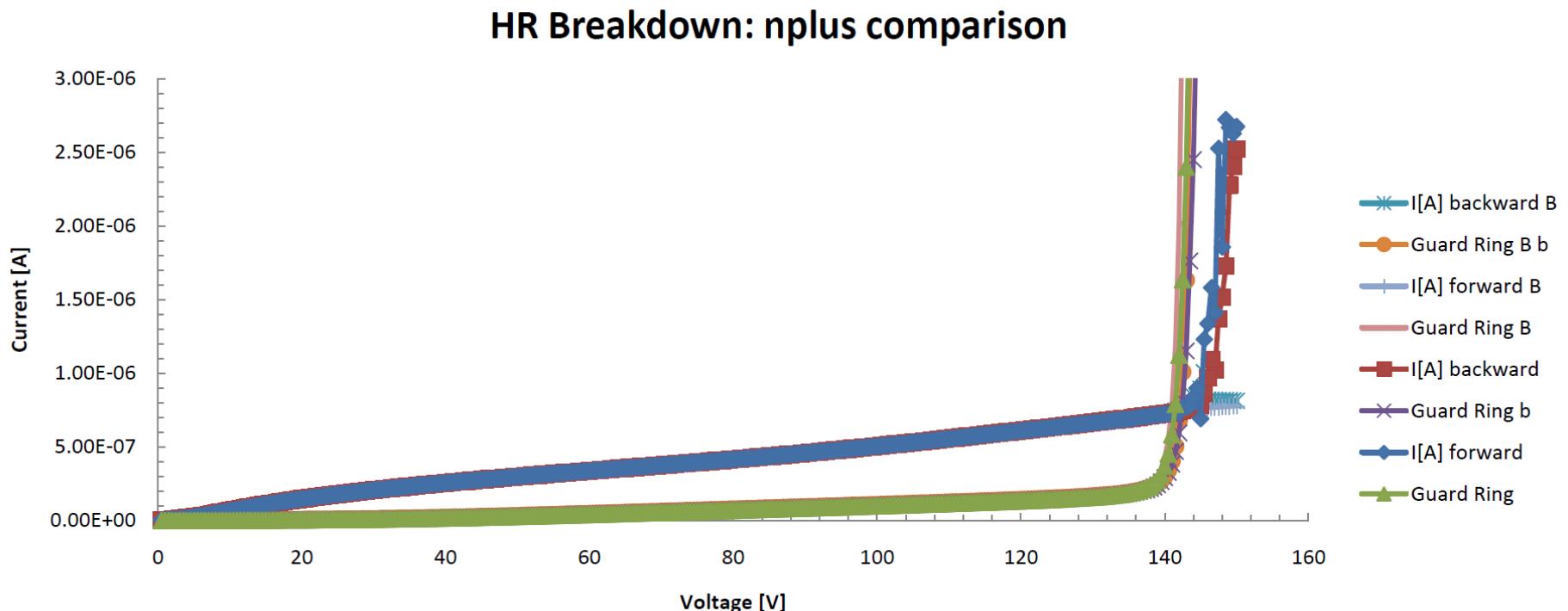
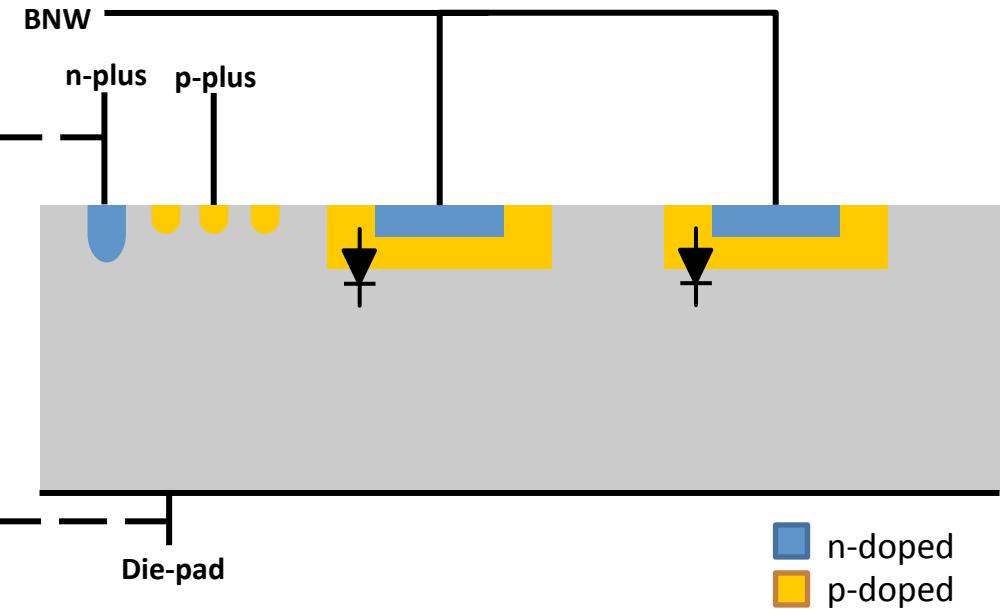
Many thermal carriers are generated when depleted to the side.
The junction is over-depleted but still doesn't break.

The Effect of n-plus

Guard ring saturates slightly more quickly.

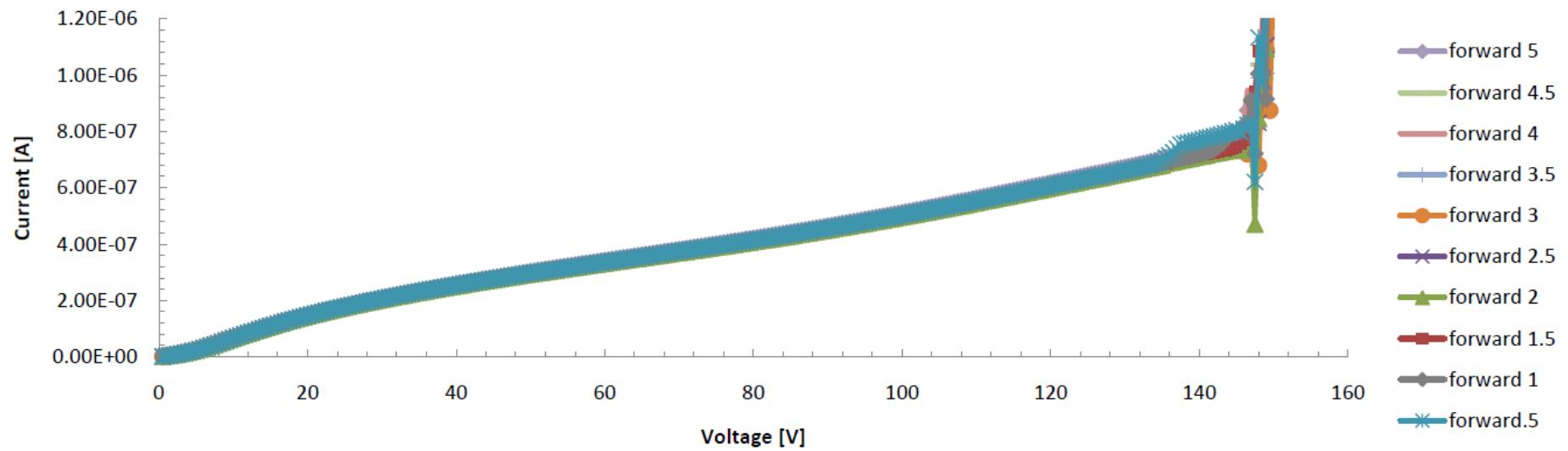
No effect on pixel breakdown

The capital B represents when n-plus is tied to the die-pad.

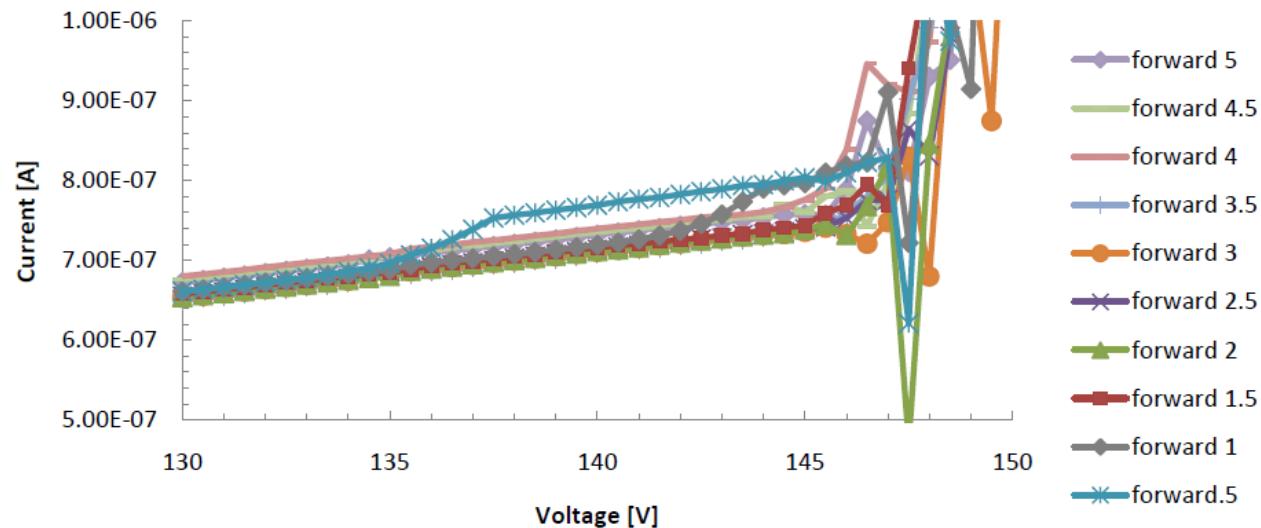


BNW Bias from 0.5 to 5

HR with varied BNW bias



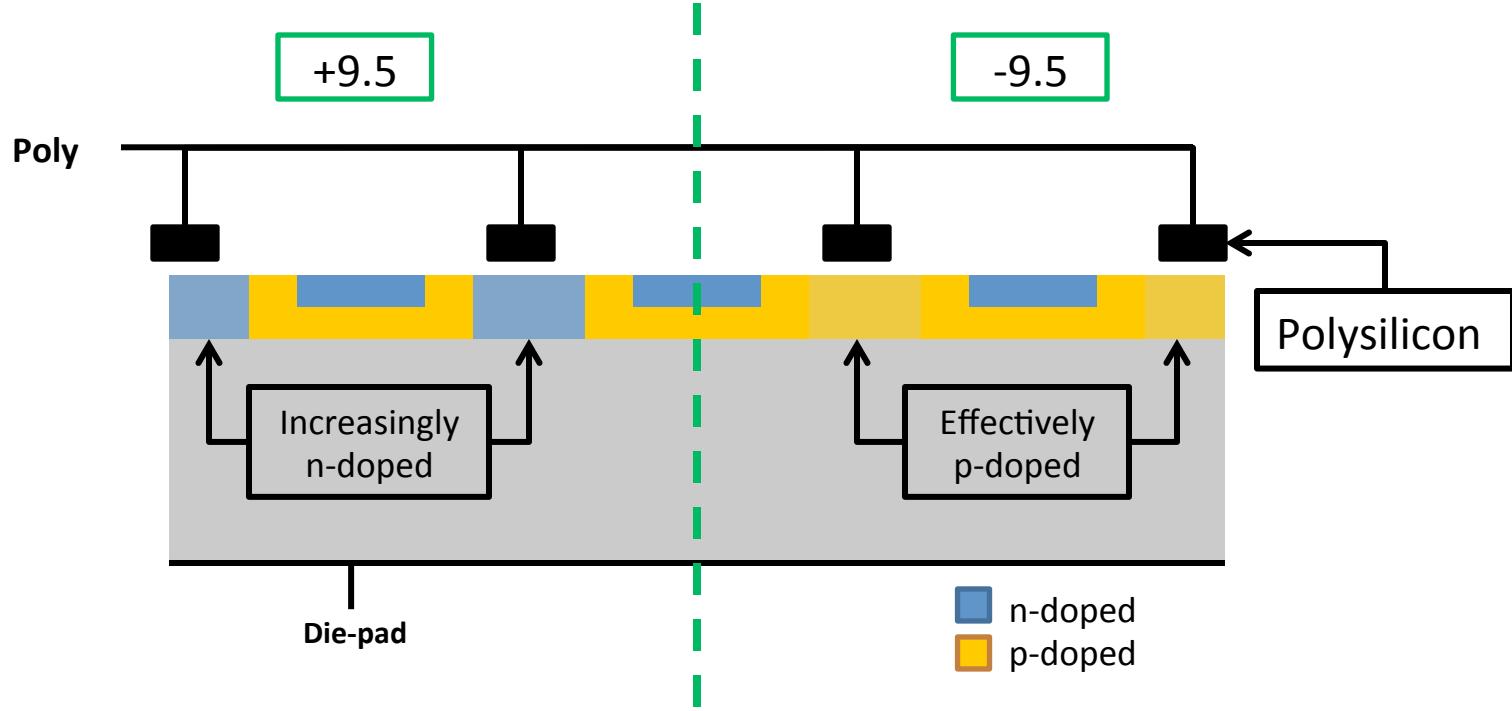
HR with varied BNW bias zoom



The largest difference is approximately $0.68 \mu\text{A}$.

This is approximately 0.4 nA per pixel (on average).

Poly Test



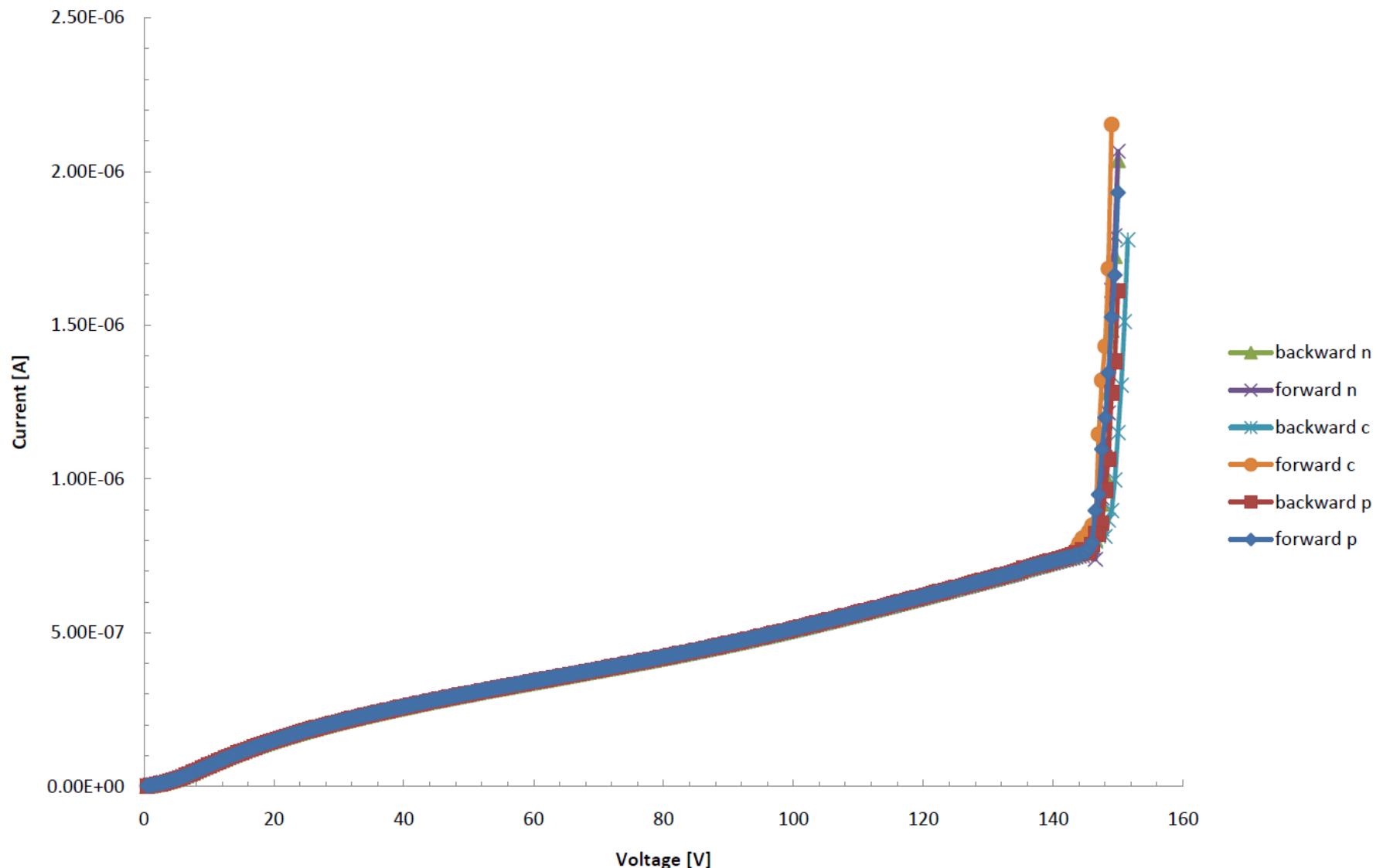
This aids in isolating each pixel so that there is a smaller level of noise than without poly being biased.

If poly is biased in the reverse direction, then the pixels effectively blend so the whole device becomes like one large pixel.

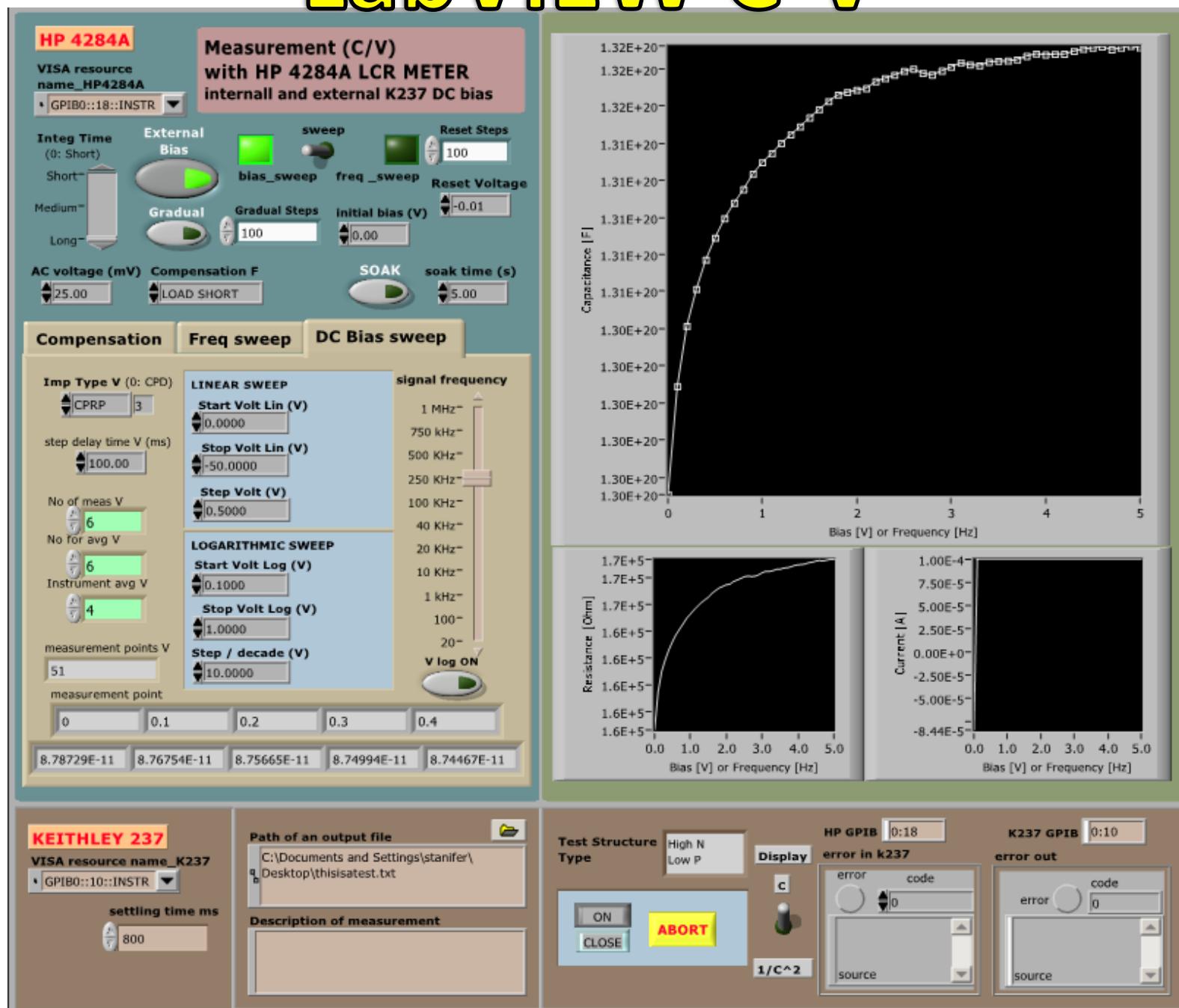
Poly Test cont.

n - negative bias
c - no bias
p - positive bias

HR Poly Comparisons

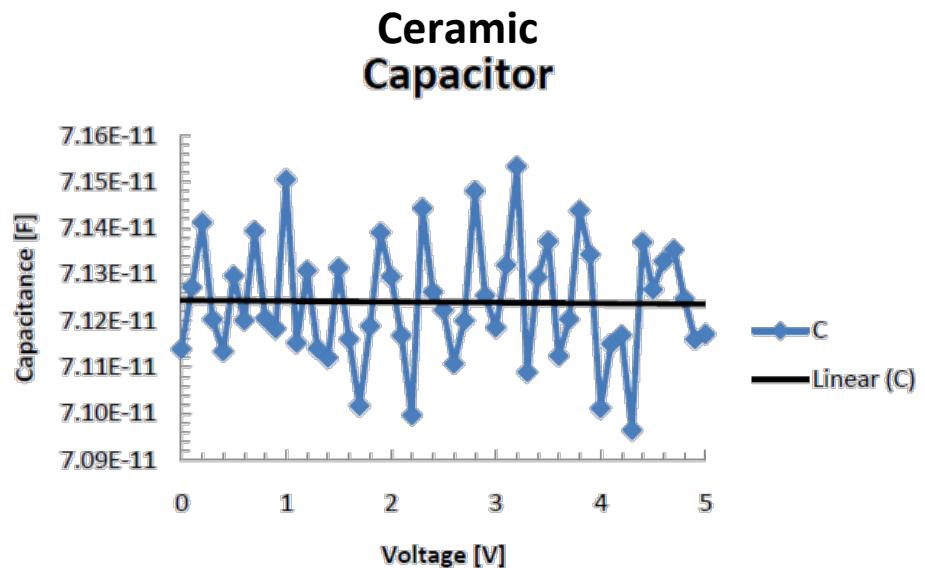


LabVIEW C-V

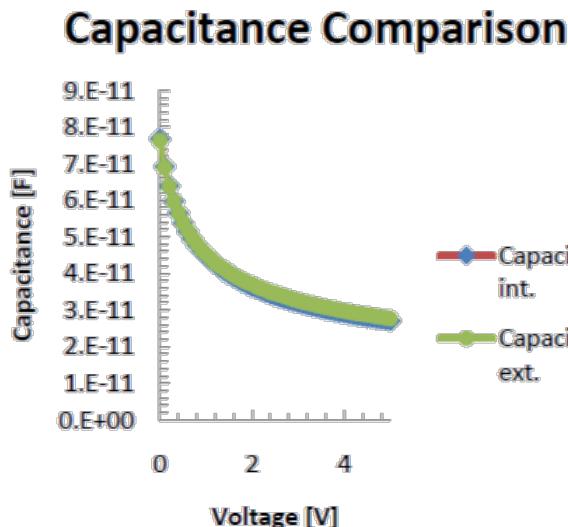


Basic Tests

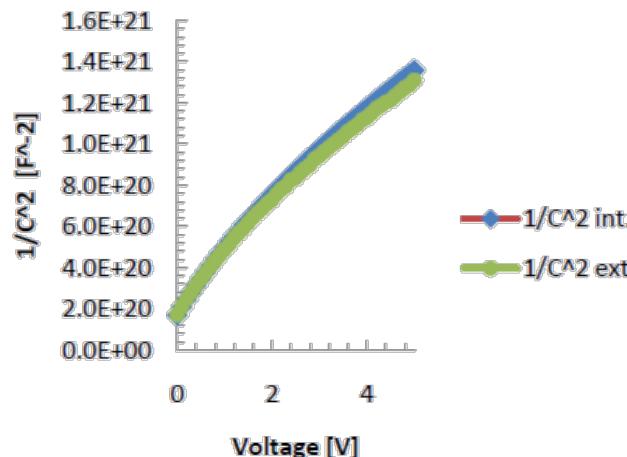
The capacitance of a capacitor was measured to be 71.24 ± 2.5 pF. The noise in the C-V plot is sub-pico. The slope of the line of best fit is $-1.7 \times 10^{-15} \pm 1.26 \times 10^{-14}$ F/V. Thus there is no appreciable effect of bias voltage on the capacitance of a capacitor.



Diode

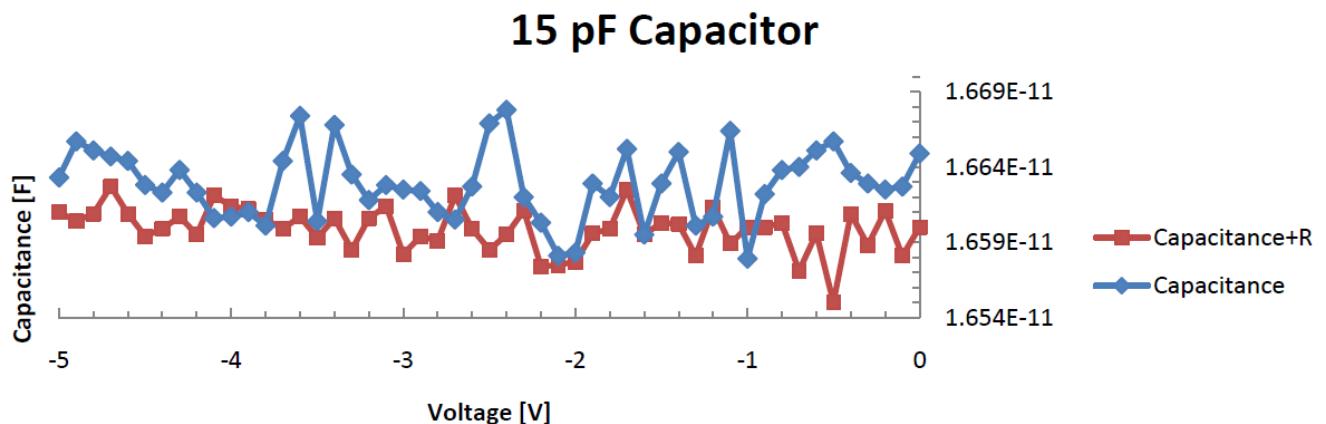
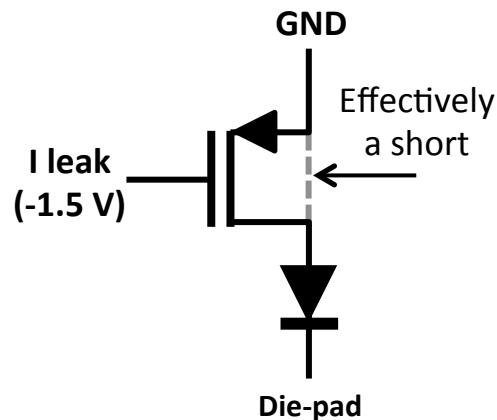


1/C^2 Comparison

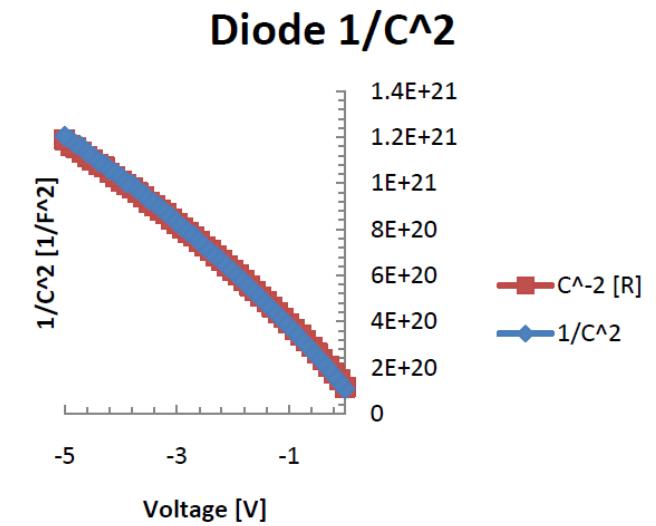
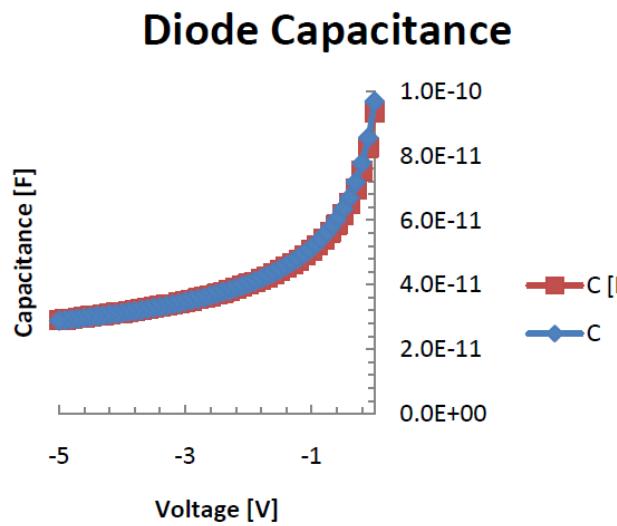
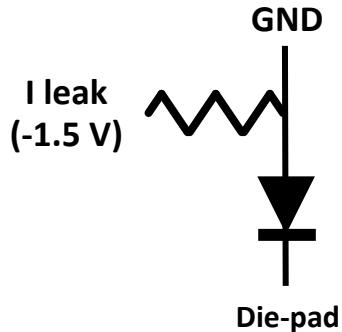


To the left is the comparison of internal bias and external bias on the capacitance of a diode in reverse bias. There is no apparent difference.

Concept Tests



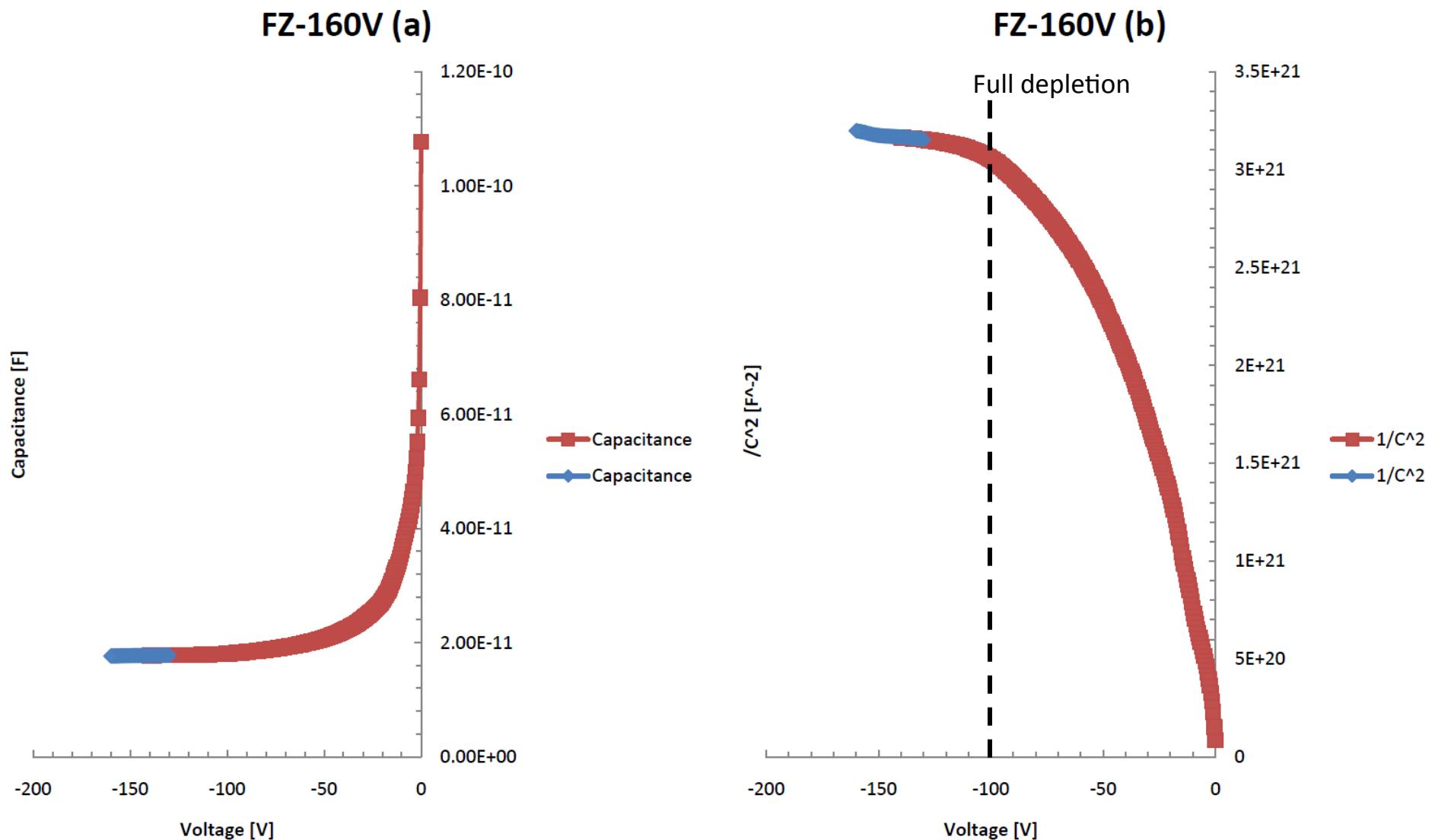
Effectively no difference



Control Data

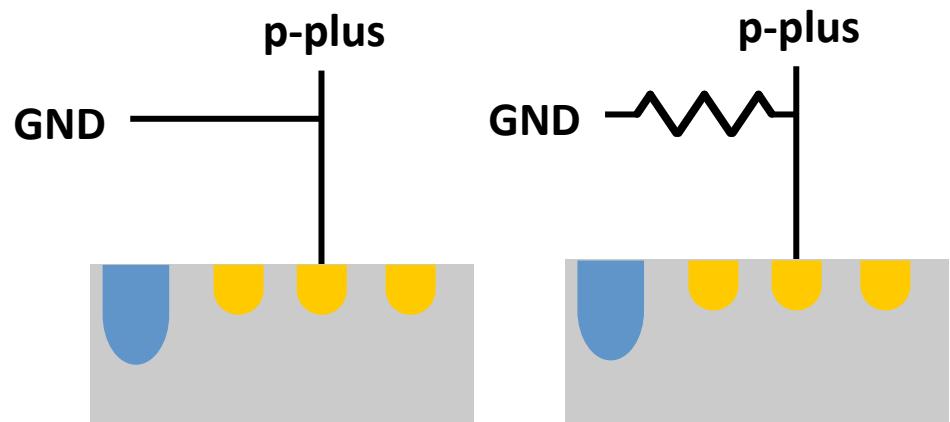
Reverse Bias

FZ: Float Zone 7.1 kΩcm
Thicker: ~485 microns

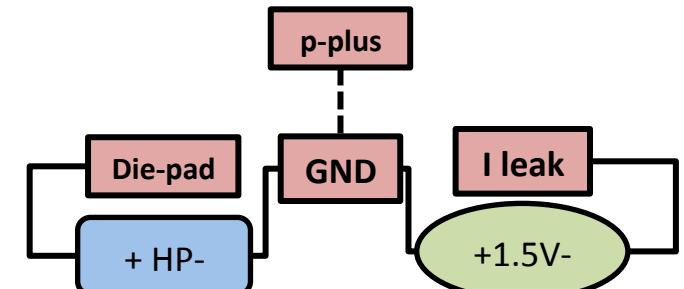
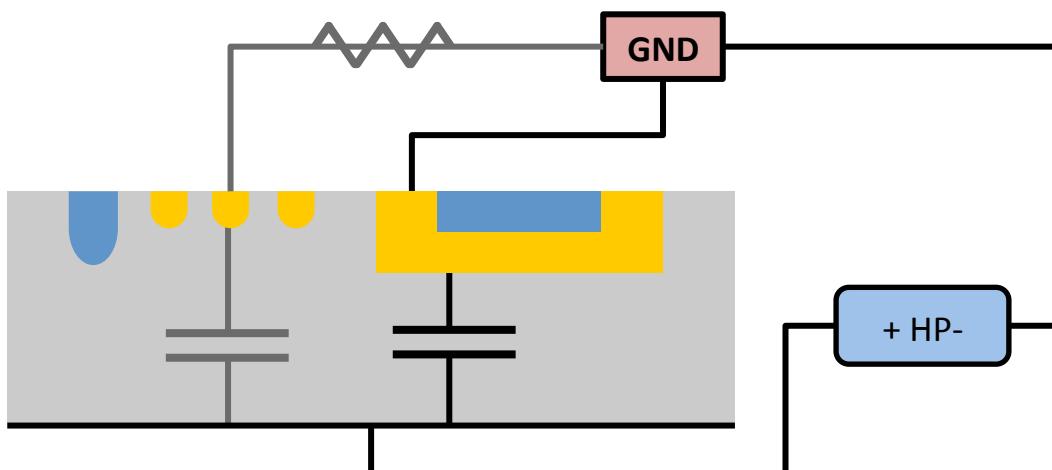


The Effect of p-plus Tied to Ground

We want to measure just the capacitance of the pixels, but the guard rings at p-plus do have an added capacitance.



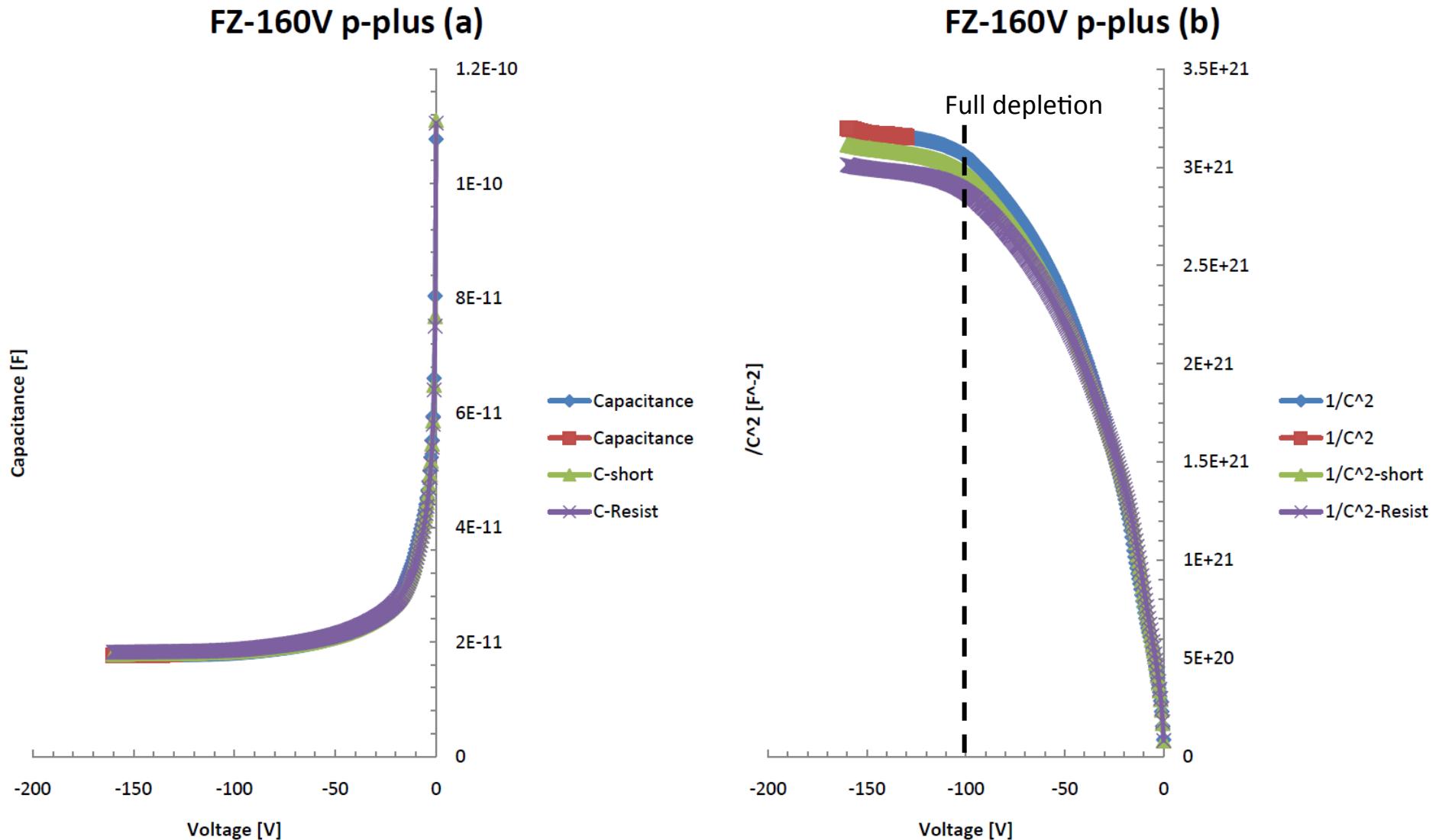
The simplest test is just shorting p-plus to ground. Another attempt is to put a resistor between p-plus and ground to help isolate the buried p-well.



Measurement Devices:
HP-4284A

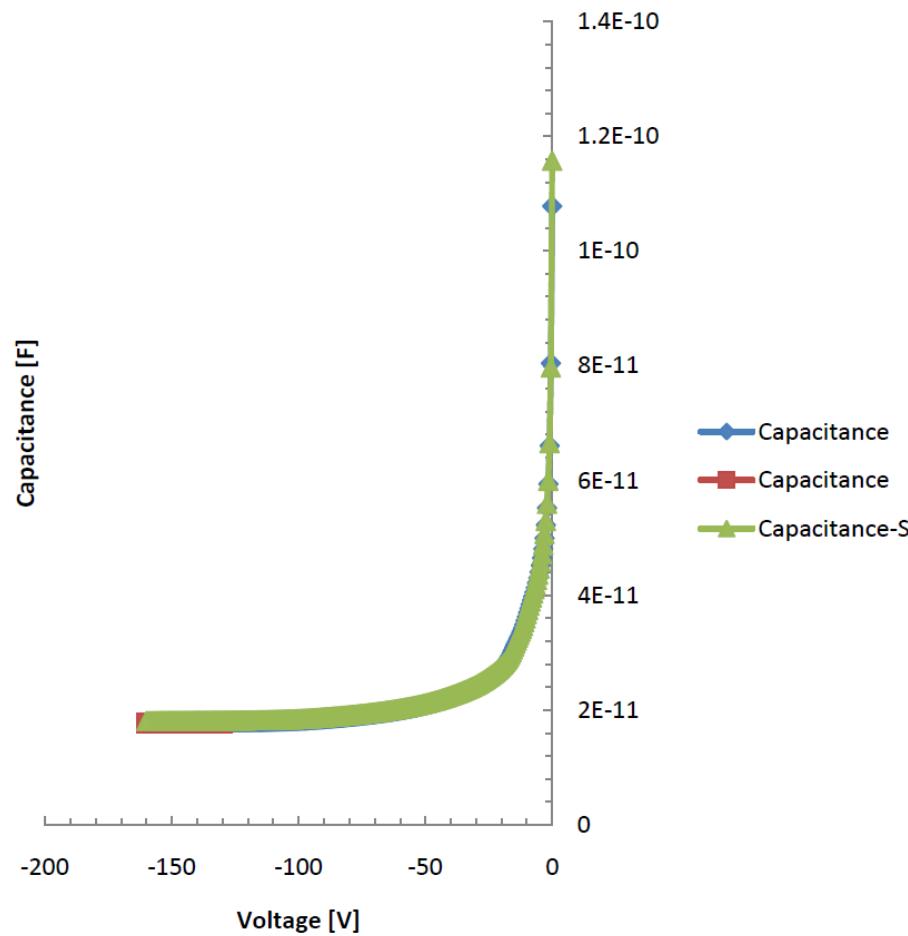
Other Devices:
1 Constant Voltage Source

The Effect of p-plus Tied to Ground cont.

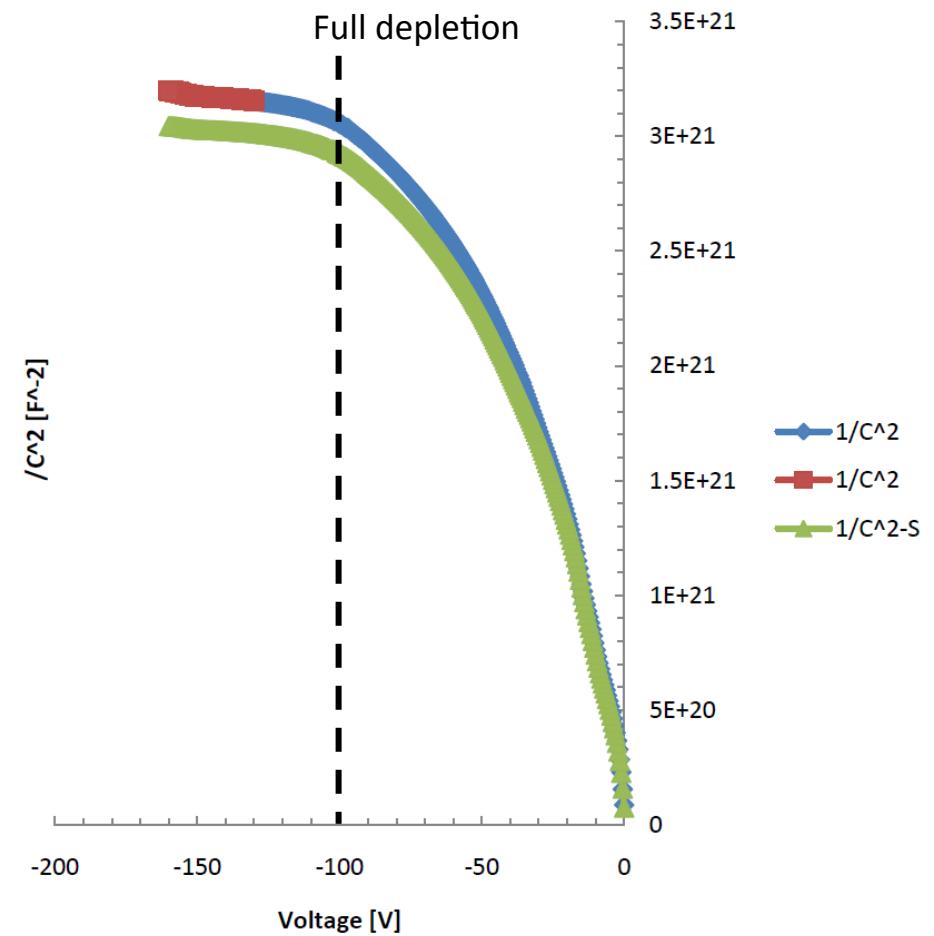


Setting on the HP-4284: CPRP and CSRS

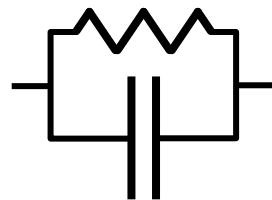
FZ-160V P and S (a)



FZ-160V P and S (b)



CPRP:

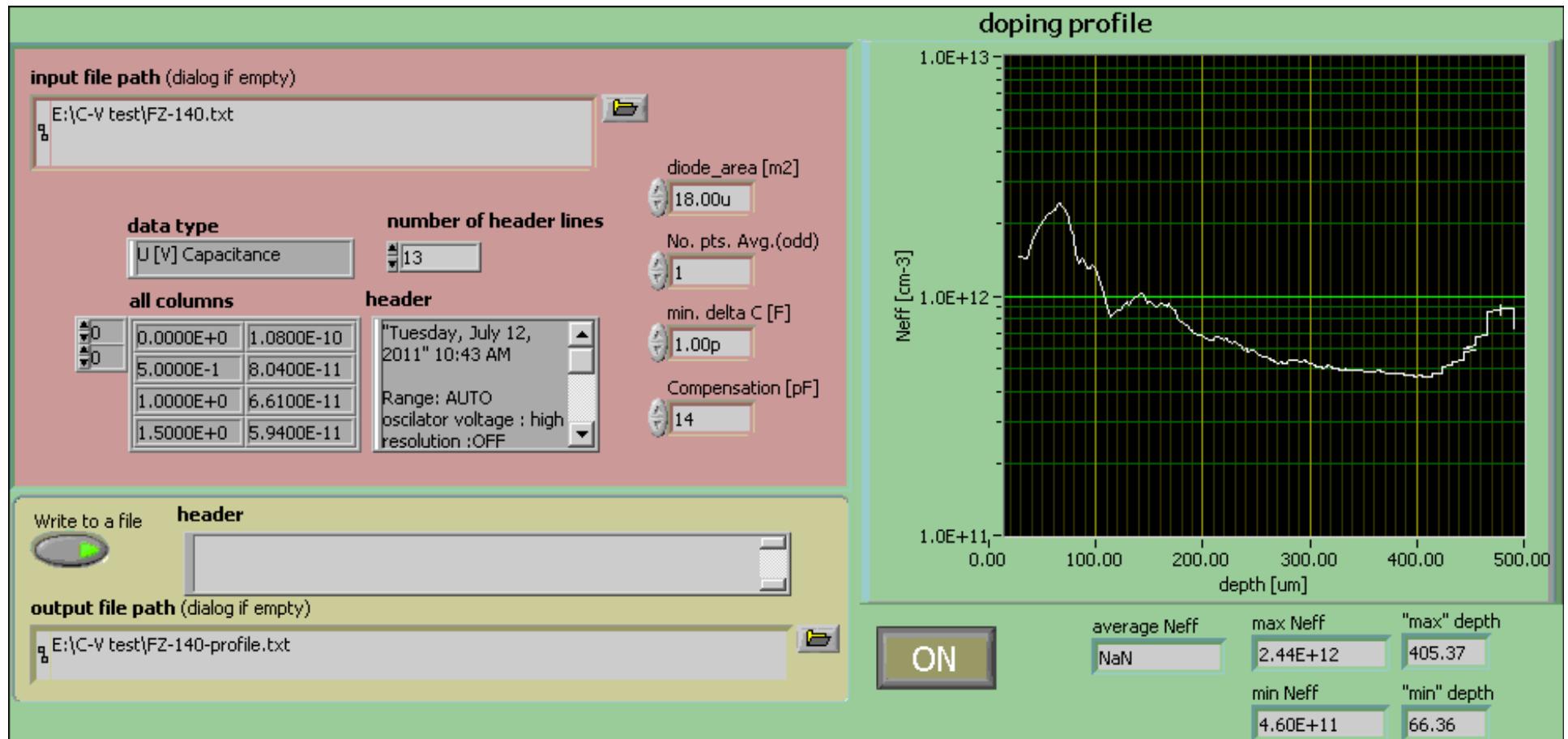


CSRS:



LabVIEW C-V Analysis

Extraction of Effective Doping Profile



Transconductance Application

